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Fine structure of spectral lines in $LiYF_4:Er^{3+}$ due to isotopic disorder in the lattice

E.P. Chukalina [a], M.N. Popova [a,*], S.L. Korableva [b], R.Yu. Abdulsabirov [b]

[a] *Institute of Spectroscopy, Russian Academy of Sciences, 142190 Troitsk, Moscow reg., Russia*
[b] *Kazan State University, 420008 Kazan, Russia*

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Abstract

We report the first observation of the resolved structure in the $^4I_{15/2} \rightarrow {}^4I_{13/2}$ infrared transition of $LiYF_4$:Er caused by lithium isotopes of the lattice. Isotope shifts of 0.019 and 0.016 cm^{-1} and inhomogeneous linewidths of 0.010 and 0.007 cm^{-1} were measured for the lines 6534.3 and 6538.3 cm^{-1}, respectively. Unresolved structure due to different erbium isotopes totals ~ 0.010 cm^{-1}. © 2000 Elsevier Science B.V. All rights reserved.

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Recent high-resolution studies have revealed an extremely small inhomogeneous broadening for the optical transitions of Ho^{3+} [1] and Er^{3+} [2] in the scheelite crystal $LiYF_4$. Inhomogeneous broadening results, mainly, from different crystal fields for different absorbing centers, due to crystal disorder, strains, impurities, and growth defects such as vacancies and dislocations. For intrinsically disordered crystal structures, inhomogeneous broadening is especially strong, typical linewidths of rare earth impurities are 30–200 cm^{-1} [3]. For ordered crystals, linewidths reduce drastically. E.g., several tenths of a wave number wide lines have been observed for $Y_3Al_5O_2$:Er (0.1%) [4]. This inhomogeneous width comes from local strains caused by the presence of point defects of the type ''yttrium at the aluminum site'' that are produced in the growth process at high temperatures (~ 1900°C). Defects of this type are absent in fluorides that grow at appreciably lower temperatures (~ 1100°C). Earlier, in $LiYF_4$:Ho we have measured inhomogeneous widths of 0.03 cm^{-1} and 0.007 cm^{-1} at doping levels of $\sim 10^4$ ppm and $\sim 10^3$ ppm, respectively [1,5]. Well-resolved nuclear hyperfine structure and isotope structure caused by isotopic disorder in the lithium sublattice have been observed in the absorption spectrum of the only holmium isotope ^{165}Ho ($I = 7/2$) in $LiYF_4$ [1,5]. Using a low-strain, isotopically pure (99.9% ^7Li) crystal of $LiYF_4$ containing ~ 1 ppm of residual erbium impurities, Macfarlane et al. [2]. have registrated linewidths of 0.0013–0.0053 cm^{-1} for the $^4I_{15/2}(1) \rightarrow {}^4F_{9/2}(1)$ transition of Er^{3+} at 15302.4 cm^{-1}. These ultranarrow lines enabled to resolve the

* Corresponding author. Tel.: +7-95-3340235; fax: +7-95-3340886.
E-mail address: popova@isan.troitsk.su (M.N. Popova).

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